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PROCEEDINGS OF THE SECOND DAY,
NOVEMBER 22, 1883.

The President, Mr. Robert J. Brown, in the chair. The following papers were read:

PRELIMINARY REPORT ON THE GEOLOGY OF NORTON COUNTY, KANSAS.

BY ROBERT HAY.

Made to the Kansas Academy of Science, Topeka, November 21, 1883.

INTRODUCTORY.

Having, in the month of August, to take charge of the County Normal Institute, at Norton, I found myself, in the early part of that month, on a dull, half-drizzly day, descending from the high prairie down the somewhat steep slopes to the valley of Prairie Dog creek. The peculiar weathering of some rough rocks near the roadside attracted my attention, and called to mind similar appearances in Trego county, and I at once determined to work out as far as possible the geology of the county in which I was about to take a sojourn.

My opportunities were exceptionally good. A medical man, Dr. E. M. Turner, was sufficiently interested in the subject as already to have made some collection of fossils, and to give me a drive out in his buggy nearly every afternoon, and with me to devote several entire Saturdays to exploration. At the end of my sojourn, the results were already so definite, that on representation of the facts, I was encouraged by our President to remain a little while longer to give some sort of completeness to my investigations, for the benefit of the Academy. The finding of a very fine lower jaw with a nearly full set of teeth just at the end of my prolonged visit made it certain that there would be full repayment for any amount of investigation, and caused Dr. Thompson and Dr. Brown to agree with me that it would be well to secure the fossils for our Kansas museum, and to desire that I should return and secure them, Dr. Brown kindly making himself responsible for the cost. The results of my explorations in both these visits are stated in the following report, to which I will only further premise, that my journeys have extended over the entire county—from the Nebraska line to the boundary of Graham county, and from close to the eastern border to within less than one township of the western frontier; and the relations of the strata were determined by observations in more than thirty definite localities, fortified by many accurate measurements and careful estimates made on the spot. There is a certain definiteness about the geological phenomena that leads us to consider this a typical county, a knowledge of whose features will enable us to determine the more readily those of several others in the same northwestern region.

REPORT.

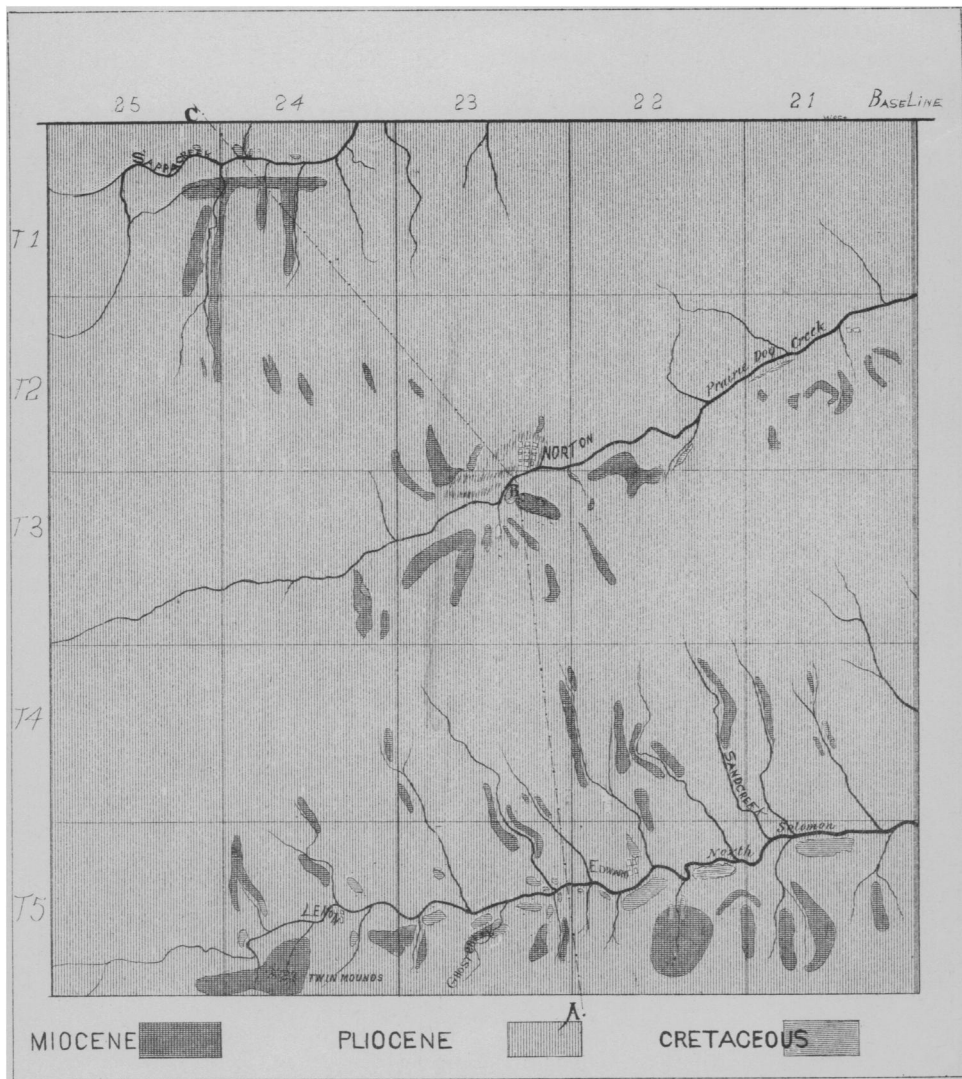
Norton county is situate in our northern tier of counties, and contains by the survey 900 square miles. It includes the first five townships in each of the ranges west of the sixth principal meridian numbered from 21 to 25 inclusive. It is the fourth county from our Colorado boundary, and the 100th meridian passes through it. The elevation of the surface is between two and three thousand feet, as is shown by Professor St. John's contour map, in the last Biennial Agricultural Report.

In considering the geology of this county, we shall investigate it under the following heads:

NORTON COUNTY,

to accompany Report on the Geology of the County by Robert Hay

NOV. 1883.



1. Potamography,
2. Stratigraphy,
3. Paleontology,
4. Economic Geology,

and shall do so with as much brevity as is consistent with definiteness of statement.

1. POTAMOGRAPHY.

Norton county has three principal streams, which pass through it in a direction nearly parallel to each other, viz., from the west to the north of east. They all enter from Decatur county, the Sappa, the northern stream, entering within two miles of the northwest corner of the county, and crossing the northern line into Nebraska about eleven miles from that point. Prairie Dog creek enters at the southwest corner of town three, passes through all the five ranges, and enters Phillips county at the northern line of town two. The North Fork of the Solomon river is the most southern of these streams, and it has rather less northing in its course than either of the others, its exit into Phillips county being less than five miles further north than its entry from Decatur. Its course is entirely in town five through each of the ranges. The tributaries of all the three streams are but small creeks which cut deep ravines into the body of the high prairie which separates the three valleys. The tributaries of each of the three main streams are longer on the northern than on the southern side of the basin, which means that the main streams are situated nearer to the south than to the north side of their drainage areas. A glance at the map shows this. Connected with this fact is this other, that the slope of the divide towards the northern stream is steeper and more abrupt than the slope towards the southern one. These facts are true also of neighboring counties, and also of streams in more distant parts of the State, and also in regions far removed from our State boundaries. The same facts of the stream seeking the southern side of its trough, and the steep escarpments of that southern side, are true also of many short tributaries of tributaries in Norton and other counties. For the explanation of this we must seek not merely to understand the effects of recent erosion, but go back to continental if not terrestrial causes operating in the ages we call geologic.

In the absence of any regular survey, it is difficult to form estimates of the relative elevation of the beds of these main streams, yet it is generally believed in the county, by intelligent persons, that the valley of the Prairie Dog is higher than that of the Solomon, and that of the Sappa than either of the others. Also, that the divide north of each stream is higher than that on the south; *i. e.*, there is a general increase of elevation of the surface *northward*. The direction of the streams is proof that it also increases westward. The Central Branch U. P. Rly. runs up the Solomon Fork as far as Lenora. The report of its engineers, kindly furnished by Superintendent Fagan, enables us to estimate the westerly ascent. The difference of elevation between Edmund and Lenora is 156 feet, which gives an increase of about 14 feet to the mile. The elevation northerly is not much less, that of Prairie Dog valley being probably 150 feet higher than that of the Solomon, and that of the Sappa from 80 to 100 higher than that of the Prairie Dog. This fact has a bearing which will be noticed further on. The exact figures which determine the full value of that bearing, can only be arrived at by a survey with instruments of precision.

The final fact of the Potamography of Norton county is, that the valleys are all valleys of erosion. Every depression below the level of the highest of the high prairie is due to the erosive action of water, aided by those agencies of varying temperature, force of wind, and other things we include under the term *weathering*. This erosion lays bare the face of the rocks in the ravines, and the study of it gives us the information necessary to illustrate our second head, viz.:

2. STRATIGRAPHY.

We recognize in Norton county six distinct strata, two of which belong to Niobrara

cretaceous; two others have so small a development that it is difficult to place them. They are above the Niobrara, present some cretaceous appearances, but may possibly be either Lignitic (Laramie) or positively Eocene. The other two are Tertiary. The modern alluvium is of course present in the valleys and ravines, and may be counted as a seventh stratum. Beginning with the lowest, we will briefly describe each:

No. 1. Is in its best development before weathering, a rather dark-bluish or lavender-colored shale. It is in some places very friable and brittle, in others tougher, and passes into a clay shale. Its color is much changed on exposure, becoming lighter, and in its upper layers inclines to buff. It contains a large-sized inoceramus both in the Sappa, Prairie Dog and Solomon outcrops, but we have only seen fragments. It has also numerous fish scales and fin spines, and occasionally the vertebra and teeth. We have seen a few saurian teeth, and have found in it the beaks of odontornithes—toothed birds—of at least two species. As already indicated, this stratum outcrops in each of the main valleys of the county, but in the Prairie Dog valley its upper layers lie low in the bed of the creek, and it is from wells that we have obtained its best appearance. In the Sappa valley it has a little more elevation, and in the Solomon valley it reaches from the river bed to a height of about 30 feet above it.

This blue shale passes gradually (and conformably) into the stratum above, which is mostly a bright yellow chalk. The change from one to the other is so gradual in some places, as to make it difficult to say where the line is. In other localities the line is so definite that some slight irregularities suggest unconformability, but further examination removes the idea. The greatest distinction we have observed is at two places, widely separated. One, Miller's Spring, west of Lenora, where a fine stream of water comes from under the chalk from the top of the shale; the other on the Sappa, where a depression in the shale of a few feet across is followed by all the streaks of the chalk, which is here beautifully banded. This little depression seemed to me just such a one as is often seen on the seaside sands, where a little stream entering the ocean makes its little furrow in the region between tide-marks. As it is to-day, so it was in the old Cretaceous sea.

No. 2. We very soon gave this stratum the name of the Yellow Chalk. It is chalk, and it is mostly yellow. We have seen since that Professor Cope has used the same designation for it, and this name will suit it well. It becomes in places in the southeast of the county, and over in Rooks and other counties, white; but buff and yellow are the prevailing tints. There are patches and layers of a brick-red and various shades of brown, and, in bright sunlight, a rich orange. The play of colors in some outcrops is perfectly gorgeous, particularly at Cedar gulch and Ghost creek, on the south side of the Solomon. At the latter place the bold escarpments of the chalk lying over the shale, both in contour and color, suggested a sunset by Claude Lorraine. At Norton Mill we were able to measure the thickness of the chalk. It is there about 55 feet. On the Sappa it is nearly as thick, but nowhere on the Solomon did we find it reach half that thickness, and in the southern valley it nowhere reaches so low as the line of the water in the river bed. It comes nearest to doing so at its most western outcrop, west of Lenora. This stratum presents abundant evidence of metamorphism of rock by infiltration. It has had its upper surface extensively covered by materials containing much silica, and through the cracks and water-holes water charged with silicon has percolated, penetrated the porous chalk, and changed it into various silicates, jasper, agate, and other forms. We have seen a band of fine red chalk changed into a band of jasper, the yellow streak above still remaining chalky. In crevices, (as also in the shale below,) crystals of calcite and baryta are found, and sometimes small crystals of quartz. In many of the occurrences of the chalk the upper layers are altogether silicified. In one place, northwest from Norton, these hard layers contain many cavities which are large enough for wells, and, containing much water, are so used. Many of the apertures through which water has entered

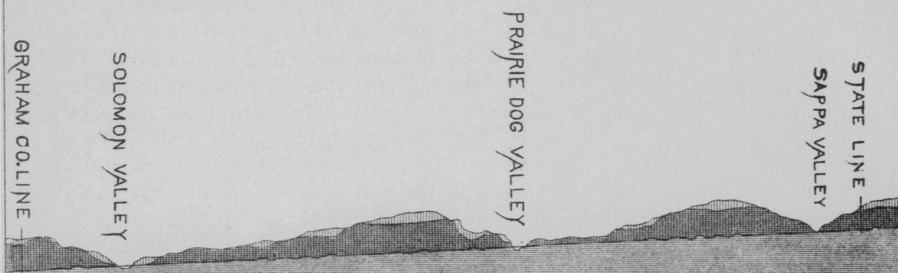
these wells are closed, and some nearly closed, by the deposit of the minerals in solution, of which silicon was among the chief—allowing us to trace the double action of water, first in wearing out a channel, and then in closing it up. The fossils of this yellow chalk are the same as in the blue shale, with the addition of the characteristic *Ostrea congesta* and the gigantic *Haploscapha grandis*.

No. 3. Is a greenish sand, which bleaches in weathering. We have found it in only in two localities certainly, and in neither place do we see it on the chalk, but it is within a few feet of where the chalk must be. We have found in it no fossils.

No. 4. Is a green clay shale, with streaks and patches of yellow; and in the outcrop where we first found it, it has a black, carbonaceous line, persistent for several rods. This green shale lies directly on the green sand in two out of three places where we observed it (both on the Prairie Dog); but in the other place, eighteen miles away, it lies directly on the chalk. Possibly the green sand is a local premonition of the green shale. The shale is about six feet thick.

No. 5. Is the ruggedest rock of the county. It occurs in bold ledges and rough crags. It is, however, very various. Prof. St. John refers to it as "irregularly bedded." This is strictly accurate. Nowhere in all the county have we seen it so that it could be described as stratified. Yet in escarpments of ten to twenty feet it gives several layers decidedly harder than the other parts, and these weather out into hard ridges. Varying much in character, it everywhere contains both sand and lime. We have called it the calcareous grit. In some places the grit is so coarse that it becomes a conglomerate held in a limey or clayey paste of various degrees of hardness; in others the sand is finer, and the lime in such quantity that it will do for mortar, and sometimes it is native lime with so little grit that it is used for plastering inside walls. It often contains limey or chalky nodules of great hardness and very tough. Again, it hardens into a building stone, and in other places its cliffs of sand have only lime enough to harden and whiten the weathered surface; and everywhere it contains cylindrical concretions, which Prof. Cope thinks may have been roots. The thickness of this No. 5 is not less than 200 feet. It comes down to within 30 or 40 feet of the level of the main streams, and in some places it is at or near the top of the high prairie. The Twin Mounds, in the Solomon valley, near Lenora, show a section of it for at least 150 feet to their very tops. A well twenty miles north pierces it to a depth of 130 feet. The wild cañons cut into it show its thickness to the same extent. The various qualities of this formation make it weather into bold and fantastic forms. In a wild ravine, southwest nine miles from Norton, it has been cut and carved by sun and wind and water into such varieties of shape, that the feeblest fancy may see turreted castles, pinnacles of churches, archways, battlements and towers. From one appearance as a cowed priest, we have named it, with the acceptance of the citizens of the county, *Monk's Cañon*. The most wonderful part of this formation is, however, its fossil remains. It is a burying ground of mammals! Here are jaws of rhinoceros, teeth of horses, shells of enormous turtles, bones and tusks of mastodon. It is the Loup Fork Miocene, the upper part of the Middle Tertiary. In 1878, Professor Mudge suggested that this formation in Trego county was possibly Miocene. (First Biennial Agricultural Report, p. 55.) Four years earlier, Prof. E. D. Cope described it as it occurs near the Colorado line, and without finding fossils, said it was probably Miocene Tertiary, (Cret. Vert., p. 19,) while at the same time he made a distinction between Miocene and Loup Fork, (p. 13.) Now the doubt is all gone. Professor Cope pronounces the jaw before us *Aphelops* from the Loup Fork Miocene. It will need further investigation to decide whether Professor Cope's *Ticholeptus* and *Procamelus* beds are distinctly marked in Kansas. One important feature remains to be noted: this Miocene is *erosively unconformable* with the strata below it. The surface of the yellow chalk was worn away to the extent of scores of feet, and left very rough by a long period of sub-aerial erosion.

GEOLOGICAL SECTION OF NORTON CO. KAS.



From S. to N. and N. by W. along line in Map marked A.B.C. Being an Appendix to Geological Report of the County by Robert Hay.

NOV. 1883.




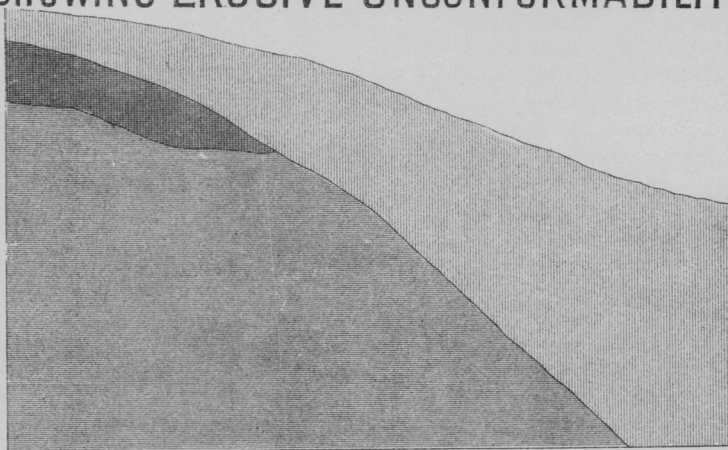


MIOCENE  PLIOCENE  CRETACEOUS 

DIAGRAM SHOWING EROSIVE UNCONFORMABILITY



MIOCENE  PLIOCENE  CRETACEOUS 

From a Section seen in a Ravine South from Edmund.

The green sand and green shale almost entirely disappeared, the valley of the Prairie Dog was cut out about to its present depth, and a long submergence filled it all up with the irregular beds of the Miocene.

No. 6. Above the Miocene is a bed of chalky, sandy marl, which everywhere gives to the high prairie a long rolling slope. In the southeast of the county it thins off, and in high places we have a sedentary soil of the Miocene. But this sandy marl is the stratum that covers more surface area than all the others together. It is formed mainly of the detritus of cretaceous rocks plus the sand of the Miocene. It contains everywhere chalk nodules, which appear to have acquired their form from fossils which no longer fill them. In one place, south of Edmund, where this formation rests on the chalk, it seems to be a layer of it, so full is it of fragments of *haploscapa* and *ostrea congesta*. This bed is in Norton county probably nowhere more than 100 feet thick now, but its thickness as a deposit must have been much greater. It lies *erosively unconformably* on the Miocene, yellow chalk and blue shale. The evidence is manifold, that after the Miocene was laid there was a long period of upheaval and erosion, during which the valleys of the main streams, the larger creeks, and even the smaller ravines were eroded out, and after that a submergence which allowed our No. 6 to fill up again from the bed of the Prairie Dog to the highest top of the high prairie and beyond; and then another elevation of the continent started the streams nearly on the old lines, and the cutting-out has now about reached the depth it was before, but not the area—for we find this last deposit resting on one side of small ravines, while the other is an escarpment of Miocene. It forms the second bottom of the Prairie Dog, and the alluvium of the first bottom is mainly made up of its materials. It forms the second bottom of the upper Solomon. As far east as Cawker City it forms the third bottom. It lies against the *sides* of chalk bluffs whose eroded *surfaces* have their hollows filled with Miocene grit. This is the Pliocene, which has so long figured in our Kansas geological sketches and maps, in which was hidden the Miocene before described. It is probably the *Equus* beds of further north and west, and it may be that it is of Pleistocene age. We have found only three bones that we are confident belong to this formation, but there are others about which the probability is great. This formation makes the smooth prairie of this and other counties, and to it the buffalo grass is most strongly attached. When it is eroded, the bunches of wire-grass get a hold in sedentary soil of the Miocene and in the flints of the upper chalk. This has occurred extensively south of the Solomon, though thick masses of it still buttress the chalk bluffs of that river.

No. 7. Is alluvium. Of this we shall say little. Its area is small, as the valleys are all narrow. Besides containing buffalo and other modern remains, it sometimes gives up a fragment of turtle shell, or a bone of a mastodon, brought from the Tertiary formations. There are three northern tributaries of the Solomon, named Sand creek, because the alluvium is entirely sand, formed from the breaking-down of the Tertiary bluffs, the Miocene here being more sandy than elsewhere. In these three creeks, the water disappears below the beds of sand for spaces varying from a quarter to a whole mile.

We must now refer briefly to the dip of the strata. It is scarcely possible to recognize any dip in the Tertiary formations. We thought we could partially do so at Monk's Cañon. Of the Cretaceous strata, (including the green shale,) there were only six places where we could fairly see the dip, or rather see that there was a decided dip, for in only two or three places could we get a section at right angles to the dip. The observations at these half-dozen places gave us a little start. The dip was not in the direction we expected for Kansas. In five out of the six places it was decidedly southeast—or a little more south than east. In the blue shale on West Sand creek, we got a fine exposure, and by the courtesy of Mr. Trescott, County Surveyor, we were enabled to take observations with instruments, and measured 195 feet of length, in which we got a dip of 14

feet. That is, about 1 in 14, or an angle of 10° . This was, however, nearly due south, and we estimated that an additional 5° would be necessary for the easting. The dip at Norton Mill is probably not more than 7° or 8° .

The fact previously assumed, that the beds of the northern streams are higher than the Solomon bed, and that the chalk is shown in each, is probably due to this southeast dip. And to this dip is probably due the other potomographic fact, that the streams are on the south side of their troughs. This fact of dip may have a bearing on the question, How deep must we go for coal in western Kansas?

There are many cracks in the cretaceous strata, and a few faults. One at Norton Mill gives a displacement of about 9 inches, and one at Mr. Trescott's 6 inches. Another at the latter place gives a break of not less than 12 feet. It is the largest we have seen in Kansas. We saw no breaks in the Tertiary.

3. PALEONTOLOGY.

On this head we can add very little to the incidental remarks made in previous paragraphs. We are indebted to Professor E. D. Cope, of Philadelphia, for the names of some of the fossils we exhibit here, but those are not given positively. A specialist should examine the specimens themselves, and more than one specialist.

We wish here to be emphatic on one point. We desire a good museum of Kansas specimens in Topeka. It is the capital of the State. Many persons will visit a collection here who will never see those at our State educational institutions. We wish the Kansas Academy of Science to make a State museum at the State capital. We succeeded in infusing this idea into our friend, Doctor Turner, who therefore gives up to us the fine chelonian specimen before us. He and I together have also preempted the side of a ravine, which has yielded the rhinoceros jaws, the tusk, and other fossils without number, the front of one of our excavations measuring 10 metres. Two other places we have actually proved to be rich in remains, one yielding these mastodon bones, and the other this large rib and fragment of tooth. Another place still, I have good evidence, will pay well in Miocene remains for any labor put upon it. All this in one county; and there are many counties in Kansas, and other formations besides Niobrara and Tertiary. We will enumerate the kinds represented by the Miocene fossils:

Mastodon, Brontotherium, Oreodon, Rhinoceros (Aphelops), Horse, and Tortoise of at least three species. The one in the photograph is *Xenobatis*. It is certain that continued excavations in more than one of the places already worked would yield almost complete skeletons. It is probable that no finer set of teeth has never been obtained than are in this jaw of a young rhinoceros. There are also fossils from this region in private hands, that can be procured if proper effort is made.

4. ECONOMIC GEOLOGY.

The useful value of the minerals of this county is great. In several places in the county, the chalk is sufficiently compact to be used for building, and is sawed into blocks for that purpose. Still more plentiful is hard, durable stone from the Miocene ledges, the jail at Norton being built of such blocks as the one before us. The soil of the county is probably as rich as that of any part of the State, containing both lime and silica. The Pliocene beds may be considered good soil to their entire depth, though lacking in organic matter. The abundant rains this fall have given sufficient illustration of the fertility of all the various soils.

The supply of water is directly connected with the condition and position of the strata. At Miller's Spring we have noticed that water comes off the shale. This is the case also on Ghost creek, while at Silver creek, a little further east, the water comes off the chalk. On the high prairie, the wells are deep, needing to reach to the bottom, or nearly to the bottom, of the Miocene grit which appears to be the chief reservoir. A proper survey which would note both dip of strata and elevation of surface would, we believe,

indicate that artesian wells would be possible and profitable in several of the northwestern counties. Where the Miocene is much cut by ravines, there is not sufficient area to store water for springs or wells. In the river bottoms, some wells are very deep, and have their reservoirs in a sand which appears to be the alluvium of the period, when the Miocene was first eroded.

As in all the Northwest, there is a general anxiety in this county about coal. At two places in the Solomon valley it is reported that small quantities of coal have been taken which burnt well; but these were not seams, but pockets in the blue shale, and were speedily exhausted. It would be interesting, had it been noted, whether this carbonaceous matter was of vegetable or animal origin, as some animal remains of the Niobrara have a lignitic appearance. The black streak in the green shale may be an indication that it belongs to the lignitic formation, but it goes without saying that the blue shale is not an indication of coal. What effect on the depth to the true coal the direction of the dip before noted may have, can only be determined by more extended investigation going over several counties. If coal be really continuous under the whole State, as it would appear that the coal measures certainly are, and if it should be shown that the northwesterly dip we have been familiar with gives place over any large area to a southeasterly dip, it would not be improbable that coal might be found in the region of the one-hundredth meridian at depths not exceeding those of the deep pits of England, or about three times the depth of the Leavenworth shafts.

There is very little stone which yields good lime when burnt. The native lime, as we have seen, is largely developed, and is of considerable utility. Of sand there is an unlimited supply. Of other minerals, crystals of calcite are most abundant in the forms occasionally of dog-tooth and nail-head spar. This is associated often with baryta, but only sufficiently to give weight and slight color to the specimens, and there is some strontium. Mostly calcite is found in the cracks of the Niobrara formations, but some large specimens, obtained south of Edmund, it appeared had been formed in the hollow of a large haploscapha. Silicates in the form of moss agate (often very imperfect) and jasper are common in the chalk, and there are some quartz crystals in nodules and cracks. Among the pebbles of the Miocene conglomerate, there is rose quartz, jasper, agate, calcedony, diorite, feldspar, and granite (rare). Fine specimens of dendritic manganese are not uncommon both in stone and bone. Some miles east of Norton there is a deposit of many acres in extent, and over four feet thick, which is very fine grained and has fine polishing qualities. It has been called emery, and it seemed to have some properties of corundum, but Prof. Failyer says it is fine silicious sand. We ask, is it an infusorial bed akin to that in the Miocene of Virginia? Will some microscopist of the Academy answer this, and if the answer is affirmative, describe its diatoms and polycystines? We found traces of the bed at one point many miles distant, and heard of it at another. It is apparently of Miocene age.

In conclusion, we wish to give credit and thanks for invaluable assistance to our friend E. M. Turner, M. D., of Norton, without whose enthusiastic aid it would have been impossible to obtain such definite results in so short a time and at so small an expense. To County Clerk Harmonson and Surveyor Trescott are also due thanks for help cheerfully rendered, and other citizens who sought to facilitate our object. The Missouri Pacific Railway officials readily gave information with regard to the elevations obtained by their surveyors, and the Union Pacific Railway gave passes, which, though arriving late, were and will be of some service.

Finally, a large part of the value of this report is due to the encouragement given to the writer by our late and present President, who guaranteed the expenses, and to whom are due the writer's personal obligations and the heartiest appreciation of the Academy.

NOTE.—The silicious sand from the Miocene was somewhat hastily examined with a microscope by Professor Cragin, during the meeting of the Academy, who reported that it did contain diatoms. A

further examination shows that it is much finer than the Infusorial earth of Virginia, and the microscopic remains are all greatly comminuted.

NOTE 2.—A fine fossil obtained from the Equus Beds (Pliocene) has been pronounced by Prof. Cope to be *Bison*. It is the right mandibular ramus, with six teeth, two teeth being much worn.

APPENDIX A.

Dimensions of fossil tortoise from the Loup Fork Miocene of Norton county, referred to in the preceding report. (*Xerobatis* [*cyclopygius*?] Cope,) found by Dr. E. M. Turner, four miles southeast of Norton:

	<i>M.</i>
1. Length of carapace along median line.....	.37
2. Length of carapace, following curve.....	.45
3. Breadth of carapace.....	.30
4. Breadth of carapace, following curve.....	.47
5. Internal height from line used in No. 1.....	.11
6. Internal height from line used in No. 3.....	.14
7. External height plastron and carapace.....	.21
8. Length of plastron on median line.....	.32
9. Extreme length of plastron.....	.34

The shell of the carapace very thin and delicate, in places has less thickness than .005.

Dimensions of rhinoceros lower jaw; *Aphelops* (Fossiger?) found, with other parts, four miles southwest of Norton, in the Loup Fork Miocene:

	<i>M.</i>
Length of jaw from the sockets of the incisors, along the line of surface of the teeth, to the back of the jaw.....	.44
Height of jaw.....	.37
Length of line of teeth.....	.21
Length of line from front of jaw to first tooth.....	.07
Length of line from last tooth to back of jaw.....	.16
Depth of jaw below premolar.....	.08
Breadth of the jaw at symphysis.....	.08
Breadth of the jaw at furthest teeth.....	.24

The last dimension is probably .03 or .04 less than the natural width, as the jaw is slightly compressed and distorted.

All these dimensions were taken before attempting to move the specimen, or covering it with plaster necessary to preserve its form.

APPENDIX B.

Elevations supplied by officials of the Central Branch Missouri Pacific Railway:

	<i>Feet.</i>
Atchison, elevation above tidewater.....	814
Netawaka.....	1,119
Blue Rapids.....	1,208
Greenleaf.....	1,435
Washington.....	1,329
Clyde.....	1,318
Concordia.....	1,392
Beloit.....	1,402
Cawker.....	1,510
Kirwin.....	1,720
Logan.....	1,912
Edmund.....	2,144
Lenora.....	2,290

APPENDIX C—Map of county.

APPENDIX D—Section across county.

APPENDIX E—Diagram of Erosive Unconformable.